United States Environmental Protection Agency
Region 5

Agricultural Pesticide Use In The Great Lakes Basin: Estimates of Major Active Ingredients Applied During 1994-1995 For The Lake Erie, Michigan, and Superior Basins

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ABSTRACT

This report describes the estimated quantities of pesticide active ingredients used for agriculture in the Lake Erie, Michigan and Superior drainage basins. The figures were derived by applying 1994 and 1995 statewide pesticide use data developed by the National Agricultural Statistics Service (NASS) of the U.S. Department of Agriculture (USDA), to 1995 county level crop data available from state agriculture departments. The Great Lakes basin has diverse agriculture, with the various states reporting significant acreage for 36 different crops. Still, corn and soybeans dominate the agricultural land use, accounting for about 70% of the reported crop acreage. Hence, the pesticides used for corn and soybeans represent the largest quantities of pesticides used. Although over 120 pesticide active ingredients are used in the basin, the top five herbicides alone (atrazine, metolachlor, cyanazine, acetochlor and alachlor) account for about 53% of the total volume. These ingredients are primarily applied to the sourthern Lake Michigan and western Lake Erie Basin.

INTRODUCTION

The application of pesticides in the Great Lakes Basin has been a cause of concern for environmental managers due to their potential to harm the basin's critical ecosystems. The Great Lakes Water Quality Agreement as Amended in 1987, states that Lakewide Management Plans (LaMPs) should

> "provide a continuing historical record of the assessment of Areas of Concern or Critical Pollutants, proposed remedial actions, and their method of implementation.... They are to serve as an important step ... toward restoring and maintaining the chemical, physical and biological integrity of the Great Lakes Basin Ecosystem.[1]"

The LaMPs, which are currently in preparation for Lakes Erie, Michigan, and Superior, require information on the application of pesticide in the basin. While the Pesticide Program Staff in Region 5 have tracked pesticide use data on a state by state basis for several years, this request was an opportunity for analysts to focus on pesticide use within the lake basins of concern.

The objectives of the study were to find out (1) what agricultural pesticides are being applied in the Great Lakes Basin; (2) where these pesticides are being applied in the Great Lakes Basin; and (3) what quantities of these agricultural pesticides are being applied. Several studies have been conducted on agricultural pesticide use in the Mid-West Region in the past. Over the years, the United States Department of Agriculture (USDA), in cooperation with the States, have provided State data on agricultural pesticides. The US General Accounting Office published a report which incorporated more detailed geography using 1991 data to estimate pesticide application by county in the US and Canadian Great Lakes Basin. In 1993, Ontario surveyed pesticide use in their basin, but only provided pesticide data in the broad categories of Triazine, Phenoxy, Fungicide, Insecticide, and Nematocides. The USGS has a better range of chemicals in their Pesticide National Synthesis Page

[1] Internation Joint Commission, Great Lakes Water Quality Agreement As Amended in 1987, Annex 2, Section 2b. p.32

based on 1995 pesticide data, but they estimate the application using 1992 crop data and their national scales admittedly make determinations difficult for decision making in the Great Lakes Basin[2].

In order to provide the Great Lakes Teams with the most appropriate estimates of pesticide application in the Great Lakes Basins, it was necessary to gather the most recent and detailed pesticide information in the basins. In the next section, the analytical process of obtaining these estimates will be presented.

ANALYSIS

As mentioned in the introduction, the Pesticide Program has been tracking pesticide use data from the USDA for several years, but these data are only provided at the State level. In order to make more informed decisions in the LaMPs, estimates had to be made in smaller geographic units and aggregated in each basin of concern.

Acres of Crops Grown in Basin

Geographic delineation within the basins were most comfortably made by associating the pesticide application data with the closely related attribute of the amount of crops planted. By assuming a uniform distribution of pesticide application on crops in the State, each county's crop acreage data could be used to estimate the amount of pesticide applied in each of the basin counties.

Both State and County crop acreage data were found in 1995 USDA annual reports. In general, these reports provided a fair amount of data on field crops. However, most reports provided only spotty information on acreage planted by county for vegetables and fruit crops. All data found were included in the analysis.

Defining the Basin

An additional effort was made to define what counties lie within the specific basins of concern. According to US EPA's Great Lakes Program Office, the Lake Erie Basin includes 64 different counties within Indiana, Michigan, New York, Pennsylvania, and Ohio. The Lake Michigan Basin is the largest with 102 counties in Indiana, Illinois, Michigan, and Wisconsin while the Lake Superior Basin is the smallest with only 24 counties in Michigan, Minnesota, and Wisconsin.

Not all of the counties are located completely within the basin. Many counties have sections of their area in two basins. For example, 98% of Washtenaw County Michigan lies in the Lake Erie Basin while 2% of the county lies within the Lake Michigan basin[3]. The percentage of each county within the different basins were estimated by visual inspection of the hydrologic unit maps supplied by the Great Lakes National Program Office[4]. Assuming a uniform distribution, these percentages were used to estimate the pesticide application in each basin of concern.

Modeling Process

In order to estimate the amount of each pesticide applied in each county, the formula

$$p_{drc} = \frac{a_{rc}}{a_{rs}}\left(p_{drs}\right) \qquad (1)$$

was used where

p_{drc} is the pounds of pesticide *d* applied to crop *r* grown in county *c*,
a_{rc} is the acreage of crop *r* grown in county c,
a_{rs} is the acreage of crop *r* grown in State *s*, and
p_{drs} is the pounds of pesticide *d* applied to each crop *r* grown in State *s*.

In order to estimate the pounds of a specific pesticide applied to each crop for the portion of each county within each basin, the formula

$$p_{drcb} = b_{cb}(p_{drc}) \qquad (2)$$

was used where

p_{drcb} is the pounds of pesticide *d* applied to crop *r* for the portion of the county *c* within each basin *b.*
b_{cb} is the percentage of county *c* in basin *b*, and
p_{drc} is from (1).

[2] USGS, "Pesticide National Synthesis Project: 1992 Annual Use," in National Water Quality Assessment, March 20, 1998, Available [Online]: <http://water.wr.usgs.gov/pnsp/use92/, index.html> [June 8, 1998].

[3] US Environmental Protection Agency Great Lakes National Program Office, Chicago, Illinois; July, 1990

[4] Ibid.

With 190 counties divided among the three basins, and 218 different pesticides used on 43 crops, the modeling effort to obtain estimates was extensive. The data were taken from USDA annual Reports for the specific states located in the basins for 1994-95; and the NASS surveys on chemical usage for field crops (1995), vegetables (1994), and fruit crops (1995). Research did not provide any other sources for information needed to conduct the study.

Clinton County, Michigan Atrazine Applied to Corn in the Lake Michigan Basin, 1995

Given the following 1995 data, an estimate of Atrazine applied to field corn in the portion of Clinton County, Michigan in the Lake Michigan Basin can be derived.

- 71,000 acres of corn planted in Clinton County
- 2,450,000 acres of corn planted in the state of Michigan
- 100% of Clinton County lies in the Lake Michigan Basin
- 1,902,000 lb. of Atrazine applied in the state of Michigan

Using the formula from (1),

$$p_{drc} = \frac{a_{rc}}{a_{rs}}\left(p_{drs}\right) = \frac{71{,}000}{2{,}450{,}000}\left(1{,}902{,}000\right)$$

= 54,968 lb. of Atrazine applied to field corn in Clinton County, Michigan.

From (2),
$p_{drcb} = b_{cb}(p_{drc})$
= 1(54,968)
= 54,968 lbs.

Therefore, it is estimated that 54,968 pounds of Atrazine was applied to field corn in the portion of Clinton County, Michigan in the Lake Michigan Basin.

RESULTS

In order to study the use of pesticides in the three Great Lakes Basins, several databases were created using estimates generated from the model. The first database was created to show the acres of crops planted in the basins of concern. Mathematically, the estimates were generated with the formula

$$\sum_c b_{ca} a_{rc} \text{ for each crop } r \text{ in basin } b\,. \qquad (3)$$

These data are shown in Table 1.

The second database was created to show the amount of each pesticide applied over all of the crops in each of the basin counties. Mathematically, the estimates were generated with the formula

$$\sum_r p_{drc} \text{ for each pesticide } d \text{ in county } c. \qquad (4)$$

These data were placed in Arcview 3.0. Some of the products are shown in this report for pesticides of major concern.

A third database was generated to show the amount of pesticide applied in each basin of concern. The formula used to generate the estimates was

$$\sum_r \sum_c p_{drcb} \text{ for each pesticide } p \text{ in basin } b. \qquad (5)$$

These data are shown in Table 2 for pesticides with application in at least one of the basins.

Although none of the pesticides studied were critical pollutants as defined by previous LaMPs, Atrazine has been identifies as an emerging pollutant of concern due to its slow breakdown rate and toxic effects in aquatic biota[5]. Other pesticides studied are of concern to other programs. In the following sections the major findings will be discussed.

The Lake Erie Basin

The Lake Erie Basin was the second largest basin studied. 8.2 million acres of crops were planted with the preponderance of agricultural land

[5] US EPA, Revised Draft Lake Michigan Lakewide Management Plan for Toxic Pollutants, September 30, 1993, p..3~4.

use on the western side of the basin. The relative acreage of each crop in the basin is shown in Figure 1.

In 1995, soybeans represented 41% of the planted acreage in the basin with more than 2.4 million acres planted. Field corn represented the second largest crop planted in the basin at 32.5% (1.9 million acres). Wheat, hay, and oats follow soybeans and corn as crops representing large percentages of acreage planted.

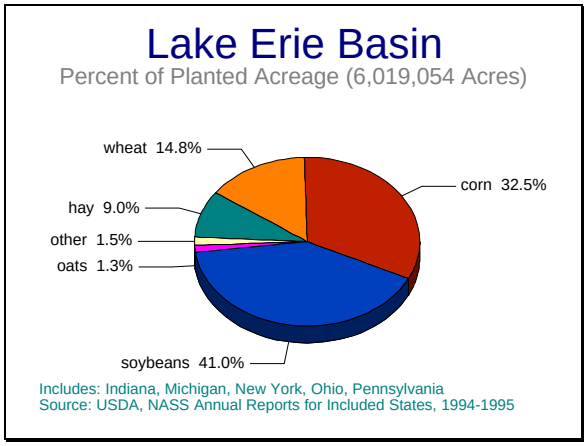

Figure 1

Pesticide use within the Lake Erie Basin was very high. As shown in Figure 2, the darker coloring in the Lake Erie basin depicts a relatively high rate of total pesticide application in the basin counties. Unfortunately, pesticide data was not available from New York, so the eastern counties are not accounted for in this report.

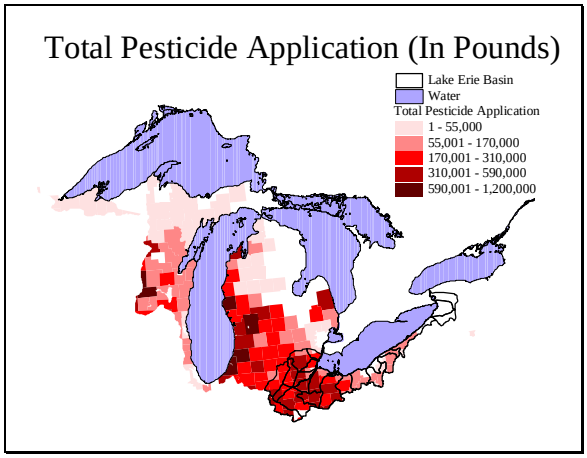

Figure 2

Figure 3 shows the relative application of pesticides applied in the Lake Erie Basin. Pesticides used on soybeans and corn represented a significant amount of the total pesticide applied. The application of two of these pesticides, Metolachlor and Atrazine, are shown in Figure 4 and Figure 5.

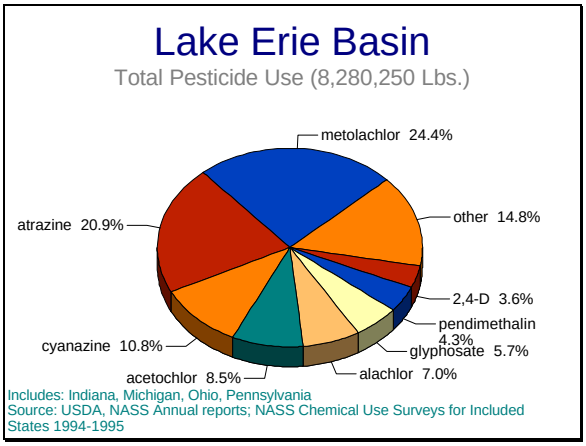

Figure 3

Metolachlor, an acetanilide herbicide, was first produced by the Ciba Corporation in 1976[6]. It is a pre-emergent pesticide used to control weeds on both corn and soybeans. In the Lake Erie Basin, Metolachlor represented 24.4% of the total pesticides used. Atrazine is from the Triazine family of herbicides. It is used as a pre and post-emergent herbicide for corn. It is used to control broad-leaf weeds. Atrazine was the second most used pesticide representing 10.8% of the total pesticide applied. In 1995 approximately 2 million pounds of Metolachlor, and 1.7 million pounds of Atrazine were applied in the Lake Erie Basin.

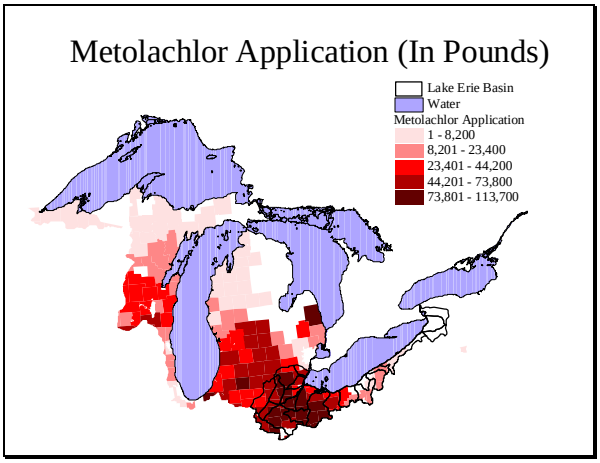

Figure 4

[6] The Oho River Valley Water Sanitation Commission, Herbicides in the Lower Ohio River Basin, January, 1997.

Table 1: 1995 Acreage Planted in the Great Lakes Basin (Quantity Applied in Acres) [7]

Field Crops	**Lake Erie Basin**[8]	**Lake Michigan Basin**[9]	**Lake Superior Basin**[10]
BARLEY	2,734	50,725	3,067
BEANS, DRY	29,187	55,064	0
CORN	1,953,475	2,536,952	4,428
HAY	539,374	1,791,674	139,752
OATS	75,600	327,150	9,153
SOYBEANS	2,470,496	1,028,853	210
SUGARBEETS	30,638	11,847	0
WHEAT	889,199	354,655	565
Total Field Crops	**5,990,703**	**6,156,920**	**157,175**
Vegetable Crops	**Lake Erie Basin**	**Lake Michigan Basin**	**Lake Superior Basin**
ASPARAGUS	0	16,272	0
BEANS,SNAP FRESH	500	450	0
BEANS SNAP PROC.	0	53,877	0
CABBAGE	500	440	0
CARROTS	347	2,965	0
CAULIFLOWER	50	330	0
CELERY	89	2,130	0
CORN SWEET FRESH	3,941	4,008	0
CORN SWEET PROC.	117	72,419	0
CUCUMBERS	365	14,900	0
ONIONS DRY	108	4,290	0
PEAS GREEN PROC.	0	28,551	0
PEPPERS BELL	210	1,117	0
POTATOES	6,422	52,510	1,140
SQUASH	267	2,690	0
STRAWBERRIES	119	486	40
TOBACCO	1,882	0	0
TOMATOES FRESH	290	1,050	0
TOMATOES PROC.	11,740	1,200	0
Total Vegetable Crops	**26,947**	**259,685**	**1,180**
Fruit Crops	**Lake Erie Basin**	**Lake Michigan Basin**	**Lake Superior Basin**
APPLES	0	48,792	0
BLUEBERRIES	0	16,885	0
CANTALOUPS	200	0	0
CHERRIES	0	34,209	0
GRAPES	0	11,880	0
PEACHES	0	6,429	0
PLUMS	0	1,663	0
PEARS	0	852	0
PUMPKINS	1,206	456	0
Total Fruit Crops	**1,406**	**121,166**	**0**
Total Acreage Planted	**6,019,056**	**6,537,771**	**158,355**

[7] Source data from USDA, NASS Annual Reports for Included States 1994-1995.
[8] Lake Erie Basin Includes: Indiana, Michigan, New York, Ohio, and Pennsylvania
[9] Lake Michigan Basin Includes: Indiana, Illinois, Michigan, and Wisconsin
[10] Lake Superior Basin Includes: Minnesota, Michigan, and Wisconsin

Table 2: 1995, Total Agricultural Pesticide Use in the Great Lakes Basin (In Pounds)[11]

Insecticides	Lake Erie Basin[12]	Lake Michigan Basin[13]	Lake Superior Basin[14]
ACEPHATE	507	23,510	0
AZINPHOS-METHYL	1,296	165,465	96
CARBARYL	3,238	86,930	172
CARBOFURAN	97	7,830	0
CHLORPYRIFOS	7,561	240,274	316
CLOFENTEZINE	0	2,169	0
CRYOLITE	1,198	0	0
CYPERMETHRIN	17	754	0
DIAZINON	105	385	2
DICOFOL	0	2,169	0
DIMETHOATE	380	26,191	41
DISULFOTON	13	7,827	0
ENDOSULFAN	1,915	36,393	30
ESFENVALERATE	277	2,771	21
ETHOPROP	2,107	13,090	539
FENBUTATIN-OXIDE	0	723	0
FONOFOS	565	3,627	0
FORMETANTE HYDROCHLORIDE	0	2,891	0
IMIDACLOPRID	1,165	4,531	187
MALATHION	429	56,810	0
METHAMIDOPHOS	1,236	26,714	249
METHOMYL	185	40,480	0
METHYL PARATHION	957	31,609	0
MEVINPHOS	29	172	0
NALED	19	456	0
OXAMYL	0	7,730	0
PERMETHRIN	376	21,433	6
PETROLEUM DISTILLATE	0	919,442	0
PHORATE	1,621	12,106	415
PHOSMET	704	101,915	124
PIPERONYL BUTOXIDE	109	897	0
PROPARGITE	0	37,487	0
TEFLUTHRIN	831	1,462	0
TERBUFOS	289	71,890	203
THIODICARB	905	920	0
Total Insecticides	**28,131**	**1,959,053**	**2,401**

[11] Source data from USDA, NASS Anuual Reports: NASS Chemical Use Surveys for Included States, 1994-1995.
[12] Lake Erie Basin Includes: Indiana, Michigan, Ohio, and Pennsylvania.
[13] Lake Michigan Basin Includes: Indiana, Illinois, Michigan, and Wisconsin.
[14] Lake Superior Basin Includes: Minnesota, Michigan, and Wisconsin.

Herbicides	Lake Erie Basin	Lake Michigan Basin	Lake Superior Basin
2,4-D	296,283	116,443	101
ACETOCHLOR	703,502	503,851	133
ACIFLUORFEN	69,904	3,157	0
ALACHLOR	577,008	586,001	490
ATRAZINE	1,729,519	1,849,890	1,968
BENTAZON	257,974	28,909	28
BROMOXYNIL	14,408	42,682	15
CHLORIMURION-ETH	17,715	799	0
CLETHODIM	777	877	1
CLOMAZONE	3,873	5,505	0
CYANAZINE	893,148	1,003,618	1,134
DCPA	68	278	23
DICAMBA	165,724	258,329	482
DIMETHENAMID	131,470	99,968	297
DIURON	0	47,463	0
EPTC	109	116,752	0
ETHALFLURALIN	198	8,089	0
FENOXAPROP-ETHYL	1,272	1,440	3
FLUAZIFOP-P-BUTYL	9,319	2,560	1
FOMESAFEN	28,390	4,033	0
GLYPHOSATE	473,361	96,441	81
IMAZAQUIN	38,254	5,308	0
IMAZETHAPYR	20,610	4,684	9
LACTOFEN	2,225	2,510	1
LINURON	90,956	28,334	705
MCPA	0	259	0
MCPB	0	3,965	0
METOLACHLOR	2,018,795	1,696,016	3,108
METRIBUZIN	143,067	22,281	145
NAPROPAMIDE	1,189	1,848	67
NAPTALAM	292	11,920	0
NICOSULFURON	4,710	10,816	16
NORFLURAZON	0	2,230	0
ORYZALIN	0	725	0
OXYFLUORFEN	16	696	0
PARAQUATE	0	30,946	0
PEBULATE	1,513	626	0
PENDIMETHALIN	359,263	188,308	399
PROMETRYN	153	3,651	0
PYRIDATE	23	20	0
QUIZALOFOP-ETHYL	16,089	2	0
SETHOXYDIM	16,610	3,639	4
SIMAZINE	0	64,708	0
TERBACIL	17	7,107	6
THIFENSULFURON	990	80	0
TRIASULFURON	0	10,399	0
TRIFLURALIN	11,289	25,913	56
Total Herbicides	**8,100,083**	**6,904,076**	**9,273**

Fungicides	Lake Erie Basin	Lake Michigan Basin	Lake Superior Basin
ANILAZINE	48	1,141	0
BENOMYL	44	27,341	11
CAPTAN	1,151	647,391	204
CHLOROTHALONIL	56,511	393,183	4,560
CU HYDROXIDE	7,792	52,121	155
CU OXYCHLORIDE SULFATE	23	47,115	0
CU RESINATE	1,198	3,588	0
CU SULFATE	1,621	26,612	415
CYMOXANIL	162	1,007	41
DIMETHOMORPH	81	503	21
DODINE	0	14,528	0
FENARIMOL	0	6,689	0
FERBAM	0	27,101	0
IPRODIONE	110	16,662	19
MANCOZEB	33,079	422,489	4,332
MANEB	229	25,574	0
METALAXYL	1,020	9,294	175
METIRAM	10,213	329,625	2,612
MYCLOBUTANIL	0	12,793	0
OXYTETRACYCLINE	0	351	0
PROPICONAZOLE	10	1,142	0
PROPAMOCARB HYROCHL.	405	5,209	104
STREPTOMYCIN	0	5,783	0
SULFUR	0	1,310,824	0
THIOPHANATE-METHYL	35	4,824	8
TRIADIMEFON	0	2,543	0
TRIFORINE	0	9,640	0
TRIPH'YL TIN-OH	162	4,595	41
VINCLOZOLIN	45	1,448	15
ZIRAM	0	108,188	0
Total Fungicide	**113,939**	**3,519,304**	**12,713**
Other	**Lake Erie Basin**	**Lake Michigan Basin**	**Lake Superior Basin**
DIQUAT	1,434	15,925	311
ENDOTHALL	0	2,093	0
ETHEPHON	1,450	6,745	0
GIBBERELLIC ACID	0	274	0
MALEIC HYDRAZIDE	1,818	8,419	187
METALDEHYDE	0	0	0
METAM-SODIUM	33,394	497,484	8,540
NAA	0	542	0
SULFURIC ACID	0	488,007	0
Total Other	**38,096**	**1,019,489**	**9,038**
Total Pesticide Applied	**8,280,250**	**13,401,918**	**33,422**

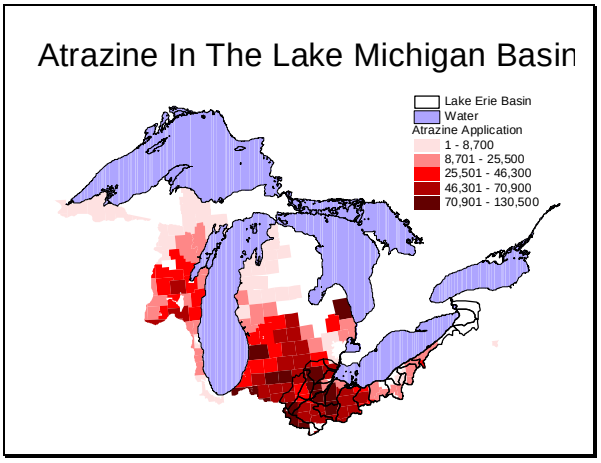

Figure 5

The relative amount of herbicides, insecticides, fungicides, and other pesticides used in the Lake Erie Basin are shown in Figure 6 through Figure 9.

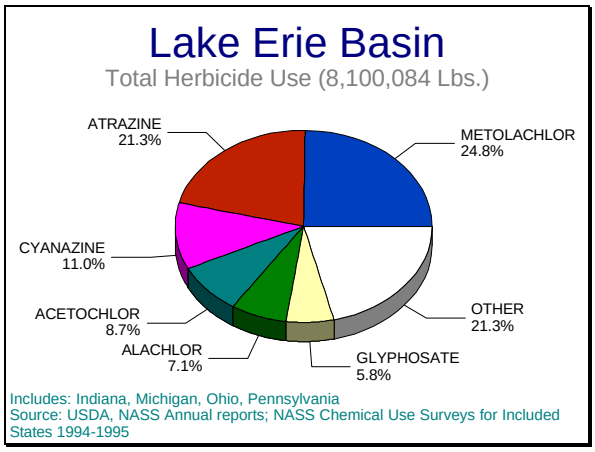

Figure 6

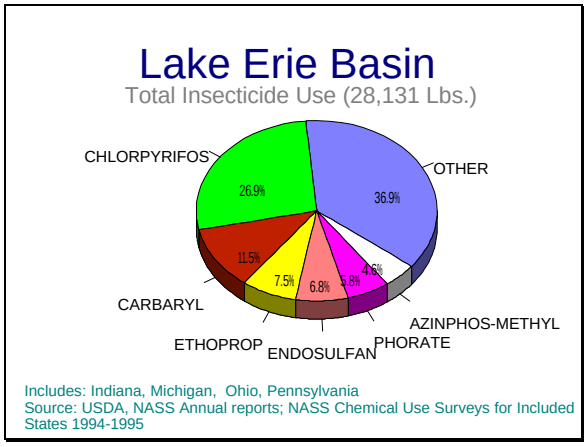

Figure 7

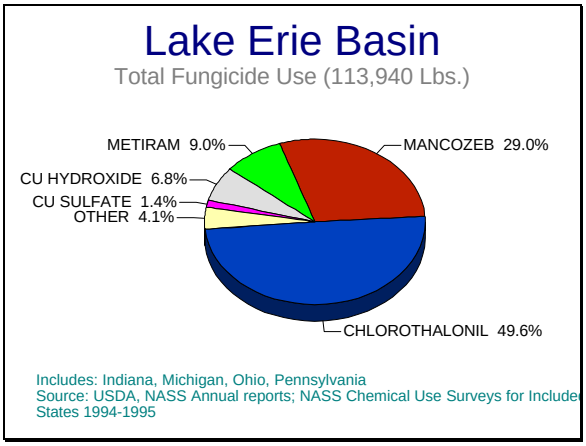

Figure 8

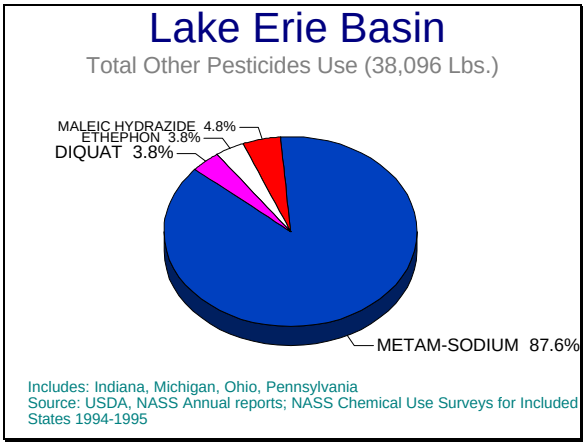

Figure 9

Lake Michigan Basin

The Lake Michigan Basin is the largest basin of the three basins studied. With 102 counties in four States, Lake Michigan is the only basin studied with the entire basin fully in the United States. The state of Michigan, with 6.5 million acres planted in 1995, had the most acreage planted in the basin. The relative acreage of each crop in the basin is shown in Figure 10.

Corn represented 38.8% (2.5 million acres) of the planted acreage in the basin. Hay was second at 27.4% (1.7 million acres). Unfortunately, USDA and NASS did not supply information about pesticide application rates to hay. However, the amount of pesticide applied to hay is thought to be minimal since the quality of hay is not as important as the quality of other crops. Soybeans were the third most prevalent crop with 15.7% (1 million acres) planted in 1995.

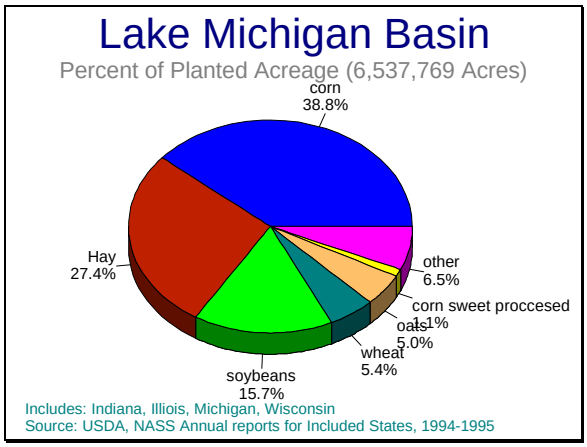

Figure 10

Pesticide used in the Lake Michigan Basin was more diverse than in the two other basins studied. Michigan reported more vegetables and fruit grown than any other state in the study, which likely resulted in wider range of pesticides used. Evidence of this diversity appears in Figure 11, where the category of *other* (pesticides used) is 36.4%, the highest of the three basins.

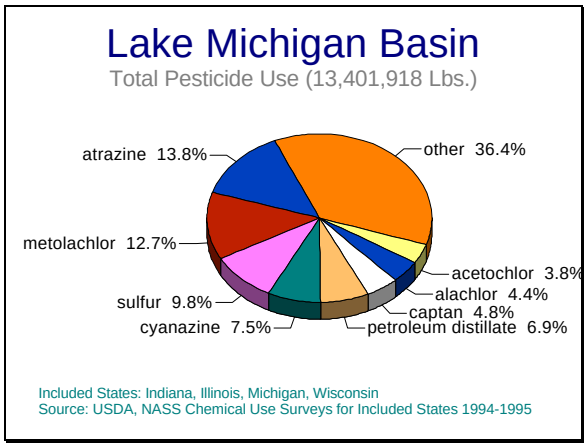

Figure 11

The distribution of Total Pesticide Application is shown in Figure 4. Most of the pesticide application was on crops planted in the southern basin, as the northern basin is highly forested. Compared with other basins studied, the majority of counties with the highest rate of pesticide application are in the southern Lake Michigan Basin. The data contains some bias, however, since little information was provided concerning pesticide application on fruit and vegetable crops in other basins.

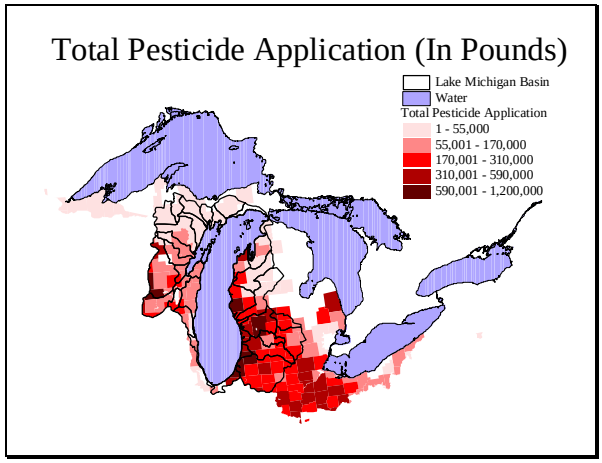

Figure 12

Even with the additional information on fruit and vegetable crop pesticide application, the field crop pesticides Atrazine and Metolachlor were still the most widely applied. Atrazine represented 13.8% of the total pesticide used in the basin with 1.8 million pounds applied in 1995. Metolachlor was the next highest representing 12.7% of the total pesticide used, with 1.6 million pounds applied. Figure 13 shows the distribution estimates of Atrazine by county while Figure 14 shows the Metalachlor estimates. In both cases, the amount of these pesticides applied in the Lake Michigan basin was similar to the amount applied in the Lake Erie Basin.

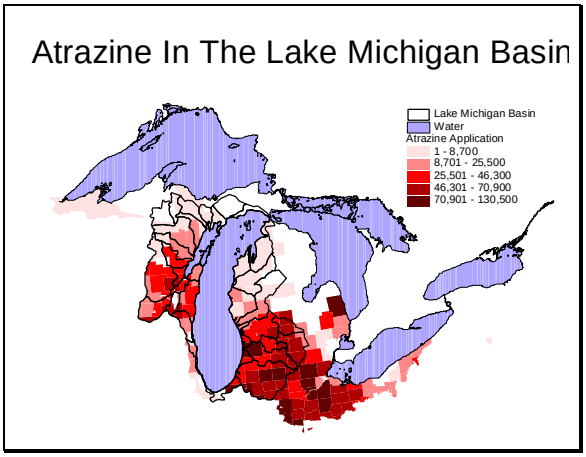

Figure 13

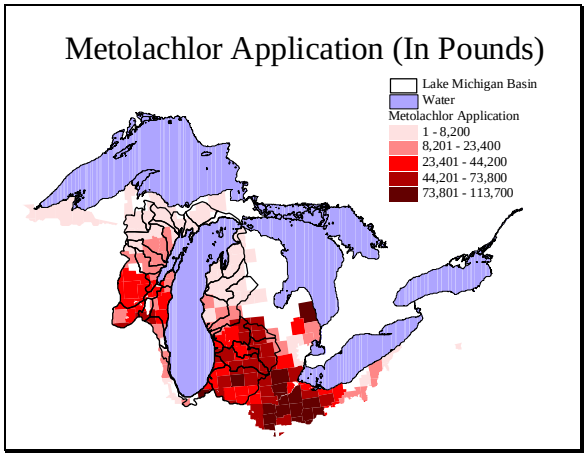

Figure 14

The relative amount of herbicides, insecticides, fungicides, and other pesticides are shown in Figure 15 through Figure 18

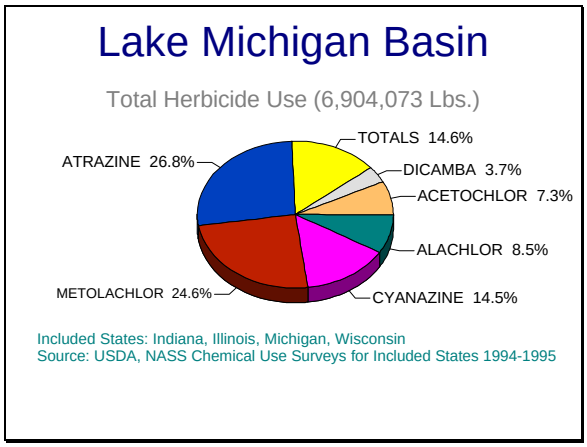

Figure 15

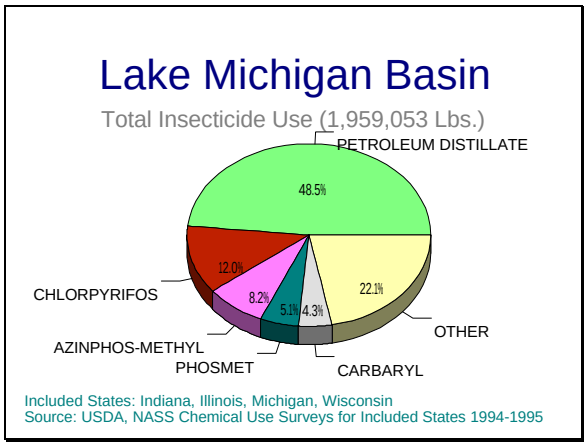

Figure 16

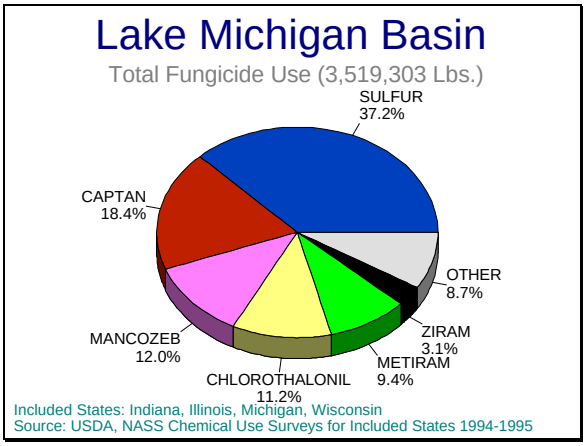

Figure 17

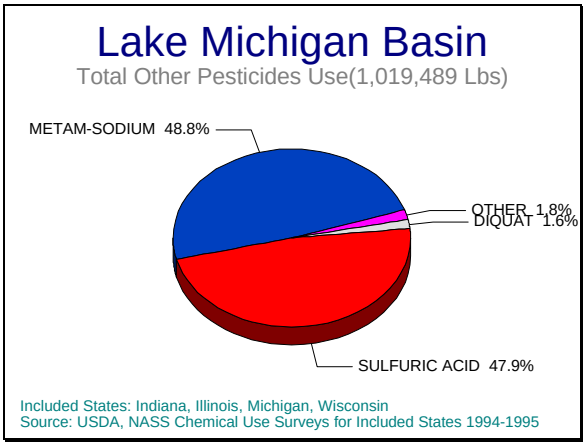

Figure 18

Lake Superior Basin

The Lake Superior Basin is the smallest basin studied in terms of land used for agricultural purposes. Most of the land around Lake Superior is forest with very little land being used for agricultural purposes. The total acreage planted in the Lake Superior Basin was 158 thousand acres 1995 compared with 6.5 million acres in the Lake Michigan Basin and 8.2 million in Lake Erie. The relative acreage of each crop in the basin is shown in Figure 19.

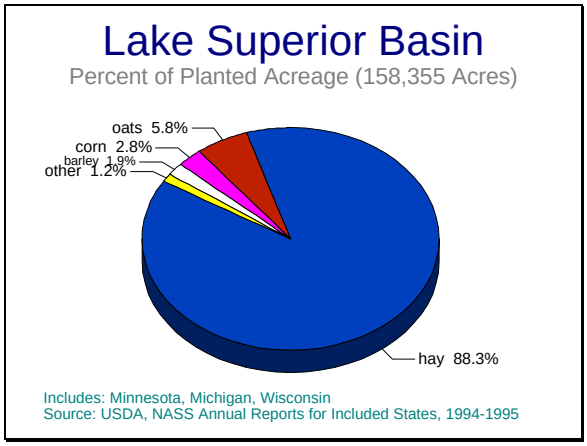

Figure 19

Hay was the most abundant crop in the Lake Superior Basin. 139,000 acres of hay were planted in 1995 representing 88.3% of the total crops planted within the basin. However, as previously discussed in this report, USDA and NASS do not provide data on pesticides applied to hay. The next largest crop grown in the Lake Superior Basin was corn representing 2.8% of the planted acreage in the basin.

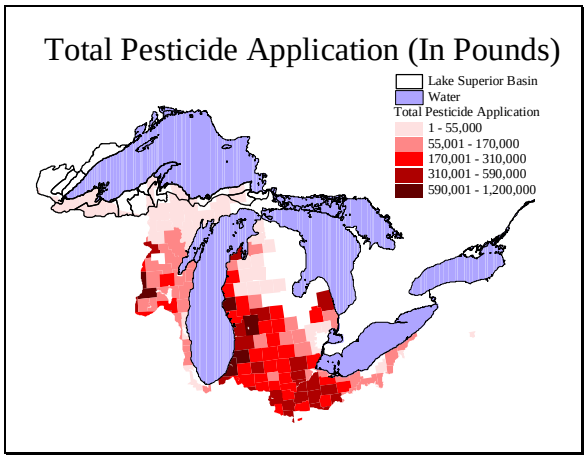

Figure 20

As shown in Figure 20, there was very little pesticide use in the Lake Superior Basin. The *total* pesticide used in the basin was 33,422 pounds. This estimate is less than the amount of Atrazine applied to most of the southern Michigan and northern Ohio *counties* as shown in Figure 5 and Figure 13.

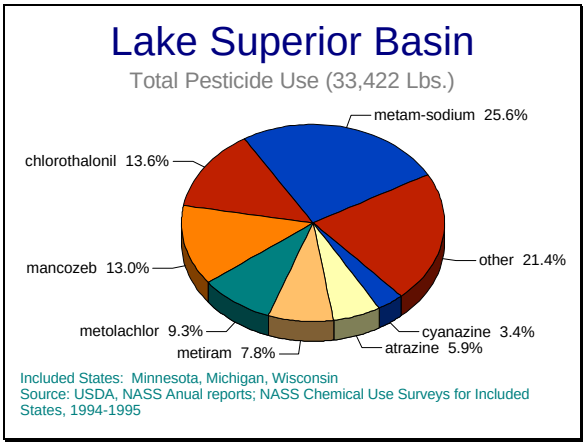

Figure 21

A very different group of pesticides were used in Lake Superior Basin compared to the Lake Michigan and Lake Erie basins. As shown in Figure 21, Metam-sodium, a fungicide applied to potatoes, represented 25.6% of the total pesticide used with 8,540 pounds applied in 1995. Chlorothalonil was second in the basin representing 13.6% of the total used with 4,560 pounds applied in 1995. The relative amount of herbicides, insecticides, fungicides, and other pesticides are shown in Figure 22 through Figure 25

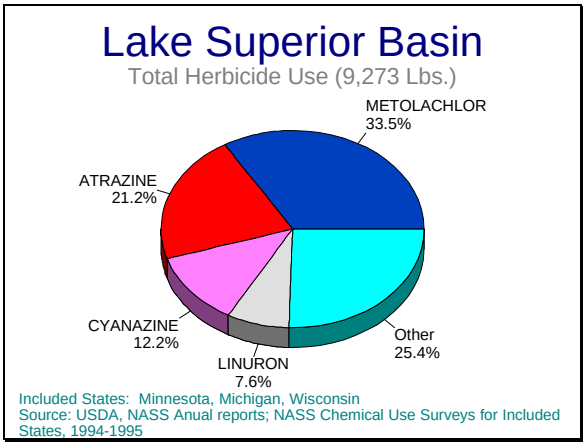

Figure 22

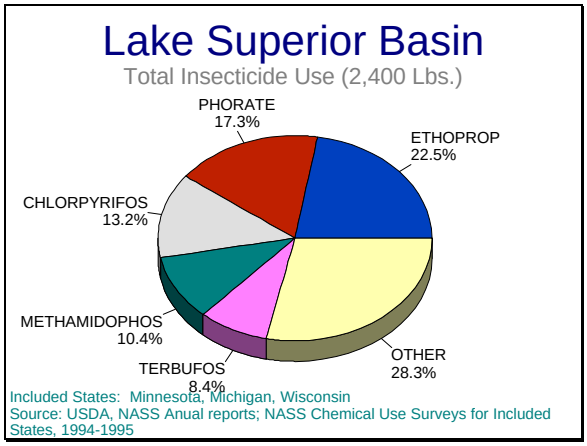

Figure 23

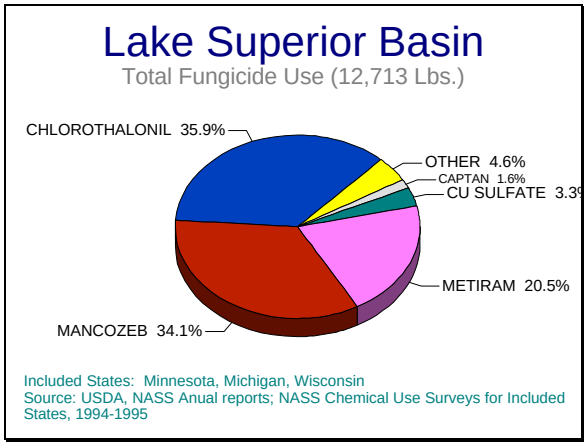

Figure 24

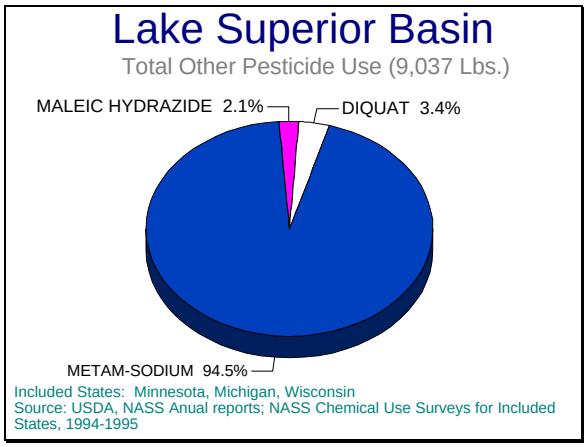

Figure 25

CONCLUSIONS

Using 1995 data, estimates of the application of 218 pesticides in the United States portions of the Lake Erie, Lake Michigan, and Lake Superior basins were calculated and analyzed. The regions most affected with pesticide were found to be the western Lake Erie and southern Lake Michigan basins. Atrazine and Metolachlor were found to be the most abundantly used pesticide in these regions. However, several areas of uncertainty remain for managers wanting to draw distinct conclusions about the threat of pesticides in these basins.

First and foremost, the State of New York. has not provided information on pesticide application in years due to a lack of funds. In order to fully describe the United States portion of the Lake Erie basin, it is imperative that quality assured pesticide application estimates are made for the State of New York.

Second, the accompanying description of the USDA and NASS data sets did not explain whether particular data points were not described because they were not detected or because they were not collected. For instance, it is uncertain whether particular crops, such as hay, did not use pesticides or if the amount was simply not reported. Several states did not report the acreage of several fruit or vegetable crops grown. Again, it is uncertain whether the number of acres of these crops is minimal, or simply not collected.

Finally, this report only describes the amount of pesticide applied in the basins of concern. The findings do not suggest that there is a precise relationship between the amount of pesticide applied and the fate of these pesticides. Several management practices have been used to reduce pesticide runoff (see Table 3). Organizations such as Resource Conservation and Development have worked with subirrigation and stream bank stabilization both in research and education. However, very little data are available depicting which farms are putting these practices into effect and to what extent.

The intention of this report was to provide the latest United States data on the application of pesticides in the Great Lakes Basin. The results and recommendations for future research should support decision makers in their efforts to reduce loadings

into the lakes of concern and gather information for further study of the problem.

Table 3: Best Management Practices (BMPs) To Reduce Agricultural Runoff

BMP	Definition	Purpose
Conservation Cover	The practice of establishing and maintaining a perennial vegetative cover to protect soil and water resources on land retired from agricultural production.	Erosion and Sediment Control
Conservation Tillage	Any tillage planting system that maintains at least 30 percent of the soil surface covered by residue after planting to reduce soil erosion by water. Also used where soil erosion by wind is the primary concern so that at least 1,000 pounds of flat small-grain residue equivalent on the surface during the erosion period.	Erosion and Sediment Control
Contour Farming	Farming sloping land in such a way that preparing land , planting, and cultivating are done on the contour. This includes following established grades of terraces or diversions.	Erosion and Sediment Control
Diversions	Channels constructed across the slope with a supporting ridge on the lower side. Used to collect runoff and move it away from the slope.	Erosion and Sediment Control
Filter Strip	A strip or area of vegetation that is useful in removing sediment, organic matter, and other pollutants from runoff and waste water	Erosion and Sediment Control. Water Improvement through filtering effect.
Grassed Waterway	A natural or constructed channel that is shaped or graded to require dimensions and established suitable vegetation for the stable conveyance of runoff.	Erosion and Sediment Control. Water Improvement through filtering effect.
Sediment Basins	A basin designed and constructed to collect and store runoff and affiliated sediments and debris	Sediment control. Could improve surface water quality by retaining sediments, but may increase the opportunity for soluble materials to be leached to groundwater.
Subirrigation	A closed system designed to retain water in field crops. Uses a systems of underground tile and reservoirs to retain water table under crops.	Water management. Effective method of retaining pesticide laden water. Costs may be greater than benefits in areas where rainfall is plentiful and additional management is necessary
Pesticide Management	Procedure to reduce the amount of pesticides used on crops and to foster the effective and safe use of pesticides without causing degradation to the environment. A central aspect of pesticide management is Integrated Pest Management, such as applying pesticides efficiently and at times when runoff losses are unlikely.	Surface and ground water quality. Costs are low and additional management is minimal.